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HOW COMMON ARE HYBRID STARS? FIRST RESULTS FROM A DISTANCE-LIMITED SURVEY
OF K BRIGHT GIANTS

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The structure and evolution of the outer atmospheres of intermediate mass ($4-6 M_{\odot}$) stars is presently one of the least understood areas in the field of stellar chromospheric and coronal research. Early ultraviolet observations with the International Ultraviolet Explorer (IUE) satellite showed that most stars fall into two distinct groups in terms of outer atmospheric structure. All dwarfs, G giants and some G supergiants have a structure similar to the Sun with chromospheres, transition regions and coronae but only weak, usually non-detectable, stellar winds. On the other hand, most K and all M giants and supergiants generally show only an extended chromosphere with little material hotter than a few $\times 10^4$ K and a strong but low velocity wind (Linsky and Haisch 1979; Brown, Jordan, and Wilson 1979; Dupree *et al.* 1979). Subsequent research has shown that the change in atmospheric structure for low mass ($1-3 M_{\odot}$) stars is relatively abrupt in terms of spectral type, both from ultraviolet observations (Simon, Linsky, and Stencel 1982) and X-ray observations (Vaiana *et al.* 1981; Ayres *et al.* 1981). While there is a large range of chromospheric activity exhibited by late G and K0 giants (Baliunas, Hartmann, and Dupree 1983; Simon 1984), by the time a roughly solar mass star becomes a K1 giant it possesses extremely little transition region or coronal plasma.

However, for more massive stars the situation is much more confused. Hartmann, Dupree, and Raymond (1980) showed that two early G supergiants, α Aqr and β Aqr, possess both transition region plasma and a strong high-velocity (~ 100 km/s) stellar wind and Hartmann, Dupree, and Raymond (1981) discovered that α Tra (K2 II-III) showed similar chromospheric properties. These stars became known as hybrid (=chromosphere) stars. Further work led to the discovery of four more K bright giant hybrids (θ Her, γ Aql, ι Aur, HD 81817) and one more G supergiant hybrid (δ Tra) (Reimers 1982; Hartmann *et al.* 1984; Reimers 1984).

In an attempt to investigate the relative abundance of hybrid stars, I have undertaken a distance-limited survey of K bright giants with the IUE satellite. All the stars classified by the Bright Star Catalogue (Hoffleit 1982) as bright giants with spectral types K1-K3 were included in the survey to a limiting visual magnitude of 4.5. Stars already known to possess hot companions were excluded. The final sample consisted of the 15 stars listed in Table 1. Four of these stars were already known hybrid stars. This survey should be complete to a distance of 200 ± 45 parsec, assuming $M_v = -2 \pm 0.5$ for early K bright giants.

The survey is only partially complete, but already some significant trends are clear. The method for investigating each star has been to obtain a deep (1-2 hr)

Table 1. Early-K Bright Giants Within 200 parsec of the Sun.

Star	HR	V	Spectral Type	Structure
β Ind	7986	3.65	K1 II	Coronal/Hybrid?
θ Her	6695	3.86	K1 IIa	Hybrid
α TrA	6217	1.92	K2 IIb-IIIa	Hybrid
	3017	3.61	K2.5 Ib-II	Hybrid?
η Pav	6582	3.62	K2 II	---
σ Oph	6498	4.34	K2 II	Hybrid
	999	4.47	K2 II-III	---
π^6 Ori	1601	4.47	K2 II	---
α Hya	3748	1.98	K3 II-III	Coronal/Hybrid?
ι Aur	1577	2.69	K3 II	Hybrid
γ Aql	7525	2.72	K3 II	Hybrid
β Ara	6461	2.85	K3 Ib-IIa	---
π Her	6418	3.16	K3 IIab	Coronal/Hybrid?
q (V337) Car	4050	3.40	K3 IIa	Hybrid
l Lac	8498	4.13	K3 II-III	---

long-wavelength high dispersion spectrum of the Mg II $\lambda\lambda 2796, 2803$ resonance doublet, which provides information on the presence or absence of a stellar wind and a deep (full IUE shift) short-wavelength low dispersion spectrum, which may be studied for the presence of transition region emission lines such as C IV $\lambda\lambda 1548, 1551$ and Si IV $\lambda\lambda 1397, 1403$. The types of atmospheric structure determined for the stars in the sample are shown in Table 1. Of the fifteen stars, six are definitely hybrid stars, one (HR 3017) has a B9-A0 dwarf companion but seems to be a hybrid star based on its Mg II line profiles and, unexpectedly, three stars appear to be either coronal stars or, less likely, a different class of hybrid star with higher wind velocity and a different velocity versus radius relationship. Based on the widths of their Mg II lines, these coronal stars are clearly bright giants rather than giants. At this stage, no non-coronal star has been positively identified in the sample.

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